

## **Biology**

### **Overview**

An extended essay (EE) in biology provides students with an opportunity to apply a range of skills while researching a topic of personal interest in the field of biology.

Biology is the science that deals with living organisms and life processes. A biology EE should incorporate biological theory and emphasize the essential nature of this subject

### **Choice of topic**

The topic must allow an approach that relates specifically to biology. Where a topic can be approached from different viewpoints, the treatment of the material must be clearly biological. For example, an EE in an interdisciplinary area such as biochemistry will, if registered under the subject of biology, be judged solely on its biological content.

Essays that deal with human diseases can often be dealt with from a number of perspectives, such as biological, medical, social or economic. Such essays should focus on biological aspects of the disease rather than on medical diagnosis and treatment.

Similarly, essays that deal with sports physiology and physical fitness must have a clear biological emphasis. They must explore the issues from a biological viewpoint and provide biological explanations for the results.

### **Inappropriate topics**

Some topics may be inadmissible because their means of investigation are unethical. For example, investigations that:

- are based on experiments likely to inflict pain on, or cause stress to, living organisms
- are likely to have a harmful effect on health, eg culturing micro-organisms at or near body temperature (37°C)
- involve access to, or publication of, confidential medical information.

In all cases where human subjects are used as the basis for an investigation, clear evidence of informed consent must be provided in accordance with the IB guidelines.

Some topics may be unsuitable because of safety issues. Adequate safety apparatus and qualified supervision is required for experiments involving dangerous substances such as:

- toxic or dangerous chemicals
- carcinogenic substances
- radioactive materials.

Other topics may be unsuitable because the outcome is already well known and documented in standard textbooks.

### Examples of topics

These examples are just for guidance. Students must ensure their choice of topic is focused (left-hand column) rather than broad (right-hand column).

Focused topics	Broad topics
The effect of detergent toxicity on soil bacteria	Detergents in the environment
A study of malnourished children in Indonesia and the extent of their recovery after a period of supervised improved nutrition	Malnutrition in children
A study of the effect of differing pH levels on the growth of <i>Phaseolus vulgaris</i>	The effect of acidity on plant growth
The competitive and evolutionary nature of the symbiotic relationship in <i>Paramecium bursaria</i>	Symbiosis
The effect of banana peel on seed germination	Factors that affect the germination of seeds
Gel electrophoresis: The construction of an apparatus and the separation of proteins in heat-treated cow's milk	Uses of the gel electrophoresis technique

### Treatment of the topic

Students should explain early in the essay how they arrived at their research question and narrowed it down, by briefly outlining aspects they are not considering in the essay.

Students should be encouraged to formulate one or more hypotheses based on the research question. A single well-formulated question may give rise to a small number of precise hypotheses.

### Primary research

Essays in biology may be based on data collected by the student through:

- experimentation
- survey
- microscopic observations
- biological drawing
- fieldwork
- or some other appropriate biological approach.

Essays that involve practical work carried out in the laboratory, or fieldwork, should include a clear and concise description of the experimental procedure.

Students taking an experimental approach must also consult secondary sources.

### **Secondary research**

Alternatively, students can base their essays on data or information obtained from literature. Ideally they can use the data and manipulate or analyse it in an original way. Essays that simply restate facts or data taken directly from the sources are of little value.

Whichever approach is chosen, the student must ensure that they have access to sufficient data or information to research the topic effectively.

Students should attempt to specify how the research approach and methodology were decided, and show any approaches that were considered and rejected.

### **Supervision**

Ideally, students should carry out the research for the essay solely under the direction of a school supervisor. Some of the IB's best essays have been written by students investigating relatively simple phenomena using standard school apparatus and this approach is to be encouraged.

All students must provide evidence in the essay of their personal contribution to the research approach and to the selection of the methods used.

Essays based on research carried out by the student at a research institute or university, under the guidance of an external supervisor, must be accompanied by [a covering letter](#) outlining the nature of the supervision and the level of guidance provided.

### **Writing the essay**

Generating and presenting data should not be an end in itself; analysis using appropriate scientific techniques is essential.

The main body of the essay should consist of an argument or evaluation based on the data or information presented. Here, the student should point out the significance of any graphs, tables or diagrams.

Students should ensure that the main body of the essay is well structured and has an obvious logical progression. They can use numbered and headed paragraphs to impose a clear structure. Their

evaluation should show they understand the results and their significance in the context of wider academic reading on the topic.

Students should provide some explanation of anomalies or unexpected outcomes as well as explore alternative explanations for their findings. If necessary, they should propose modifications to hypotheses presented earlier in the essay and suggest a research approach for testing these.

Students must be encouraged to undertake a critical evaluation of the work they have done. In their analysis, they should describe and explain the limitations imposed on the research by factors such as:

- the suitability and reliability of the sources accessed
- accuracy and precision of measuring equipment
- sample size
- validity and reliability of statistics.

They should also consider biological limitations such as:

- those arising from the problem of repeatability and control when using living material
- the difficulties of generalizing from research based on a single type of organism or environment.

### Examples of topics, research questions and suggested approaches

Once students have identified their topic and written their research question, they can decide how to research their answer. They may find it helpful to write a statement outlining their broad approach. These examples are for guidance only.

<b>Topic</b>	<b>The effect of soil salinity on the distribution and abundance of a halophyte in a salt marsh community</b>
<b>Research question</b>	To what extent is the distribution and abundance of the sea aster ( <i>Tripolium pannonicum</i> ) dependent on soil salinity?
<b>Approach</b>	Survey of vegetation using ecological techniques such as quadrat sampling to measure distribution and abundance, and a conductivity meter to measure salinity in soil samples.

<b>Topic</b>	<b>Urease from soy beans</b>
<b>Research question</b>	How does the level of urease activity differ between dried and fresh soy beans?
<b>Approach</b>	The enzyme is extracted from dried and fresh soy beans. Urease activity is measured by monitoring the pH of the solution using a suitable approach such as a pH probe or indicator.

<b>Topic</b>	<b>Antibacterial effects of a plant extract</b>
<b>Research question</b>	What evidence is there for the antibacterial properties of commercially available mouthwash on <i>Streptococcus mutans</i> (or other safe/approved strain) grown at 20°C?
<b>Approach</b>	Cultures of <i>S.mutans</i> are grown on agar plates with a suitable growth medium. Filter paper discs soaked in various concentrations of mouthwash are placed on inoculated plates and zones of inhibition are measured after a period of incubation.

### **An important note on “double-dipping”**

Students must ensure that their EE does not duplicate other work they are submitting for the Diploma Programme. For example, data collected for experiments undertaken as part of science lessons or the internal assessment task cannot be used as the basis of the EE in biology.

### **The biology EE and internal assessment**

An EE in biology is not an extension of the internal assessment (IA) task. Students must ensure that they understand the differences between the two.

- The IA is more likely to focus on the syllabus content, whereas the EE could explore aspects of biology not covered in the syllabus.
- The IA must include data collection and analysis (from hands-on experiments, databases, simulations or modelling) and cannot purely be a literature review.
- The EE must construct a theoretical framework for the underlying biology of the chosen topic, whereas the IA focuses on the application of the scientific method to a problem of interest and will only include some background information.
- The EE explicitly assesses the students’ ability to analyse and evaluate scientific arguments.

**Supervisors play an important role in guiding students on these distinctions. Students risk their diploma if academic misconduct is detected.**

## Interpreting the assessment criteria for Biology

### Criterion A: Focus and method

#### (Strands: Topic, Research question, Methodology)

The topic of the biology EE must be outlined at the start of the essay and should clearly establish the context of the research question. This should include the area of the research and the purpose and focus of the essay.

It is usually appropriate also to include the general background biological theory required to understand how the research question has arisen. For example, an essay's topic may be "Factors affecting the distribution of seagrass in Californian bays". The explanation of this topic may include reference to inshore ecosystems, pollution, the decline in seagrasses and the possible relationship to sea otter populations.

The research question is best expressed in the form of a question. It should be the precisely formulated question that the research will attempt to answer. The research question based on factors affecting the distribution of seagrass in Californian bays could be: "How do different concentrations of ammonium nitrate in sea water tanks affect the growth of seagrass (*Zostera spp*) over a three-month period?"

The research question must be:

- answerable within the limitations of resources, time and words at the student's disposal
- identified clearly
- clearly set within the academic framework of biology
- set out prominently at the start of the essay.

The student can then use the research question to formulate a hypothesis, or hypotheses, which can be tested.

Students need to demonstrate within the essay that the research has been well planned. They should show that they have researched the topic and selected an appropriate biological approach to address the research question. This applies both to their literature research and to practical data collection.

Students must demonstrate that their chosen methods and materials are appropriate for addressing the research question. They should explain their rationale for choosing practical methods. If they undertake experimental work, they must include sufficient information on their methodology for the work to be repeated.

The sources consulted must be sufficient and each must contribute to the research focus of the essay. If the study is based on the research of secondary data, students need to ensure that their selection of sources is sufficiently wide and reliable.

If students have undertaken an investigation under guidance in an external laboratory, they must clearly demonstrate:

- their understanding of the methods and materials applied
- their role in choosing and applying them.

If students are investigating a well-documented or standard topic, they should attempt to look for a new perspective on the issue.

### **Criterion B: Knowledge and understanding**

#### **(Strands: Context, Subject-specific terminology and concepts)**

Experimental work is not a requirement for a biology EE. However, a theoretical dimension must be part of any empirical investigation.

The source materials accessed should be:

- clearly relevant and appropriate to the research question
- effectively referenced and incorporated into the body of the essay in a way that demonstrates the student's understanding
- predominantly from acknowledged scientific sources.

Students need to show a mastery of, and fluency in, the use of appropriate terminology. At the same time, students need to avoid excessive use of jargon and focus on communicating clearly.

Any technical terms that are used should be explained and the student must demonstrate an understanding of these terms by using them appropriately within the text.

The student must try to maintain a consistent linguistic style throughout the essay.

Symbols, equations, significant digits and SI units should be applied appropriately and consistently.

### **Criterion C: Critical thinking**

#### **(Strands: Research, Analysis and Discussion and evaluation)**

The “research” refers to both literature sources and data collected and processed by the students themselves. This research must be consistently relevant to the research question.

Students must demonstrate the ability to apply their selected sources and methods effectively in making relevant connections and in support of their argument.

#### **Use of data**

The student is expected to analyse the data and sources and related uncertainties. This analysis will often include:

- mathematical transformations
- statistical analysis such as standard deviations and t-tests
- tables of processed data
- graphs.

If the data are analysed statistically, the student must clearly show understanding in the body of the essay of:

- why that particular measure or test was chosen
- how it was applied
- what the results mean in this context.

If graphs are used, they must be correctly selected and drawn to illustrate key elements of the analysis. They should only be included if they improve communication.

Students must analyse and present their data in such a way that they support and clarify the argument leading to the conclusion.

Students must make a special effort to maintain a reasoned, logical argument that focuses on the research question. Essays that attempt to deal with a large number of variables are unlikely to be focused and coherent. A clear and logical argument can be achieved by making repeated reference to the research question and to the hypotheses derived from it.

An assessment of the extent to which the hypotheses are supported, or the question is answered, by the data or information accessed should form part of the argument.

The stated conclusion(s) must be based on, and consistent with, the research presented in the essay. Biological research often reveals unexpected outcomes and these should be pointed out.

The original research question may not be fully answered by the investigation. In these cases, the student may point out unresolved issues and may make suggestions as to how these might be further investigated.

The student must comment on the quality, balance and quantity of the secondary sources and data used. They are also expected to show an awareness of any limitations or uncertainties inherent in their approach. In particular, they should critically comment on the validity and reliability of their data relative to their management of variables within the investigation.

## **Criterion D: Presentation**

### **(Strands: Structure, Layout)**

This criterion relates to the extent to which the essay conforms to accepted academic standards in relation to how research papers should be presented. It also relates to how well these elements support the reading, understanding and evaluation of the essay.

#### **Structure**

Students may use numbered and headed paragraphs to impose a clear structure. Subheadings should not distract from the overall structure of the essay or argument presented.



## **Recording experiments**

Students should aim for scientific paper style, rather than a cookery book recipe approach. The record should include:

- a scientific annotated diagram to introduce key elements of the set-up
- relevant details of key equipment
- a summary of the essential procedural steps.

Students should avoid including minor or irrelevant details and repetitions, but must include those elements needed for reliability and replicability.

## **Charts, images, graphs and tables**

- Any graphs, figures or tables generated by students or taken from literature sources must be carefully selected and labelled. They should only be used if they are directly relevant to the research question, contribute towards the understanding of the argument and are of a good graphic quality.
- Students must accompany images, charts and tables with analysis and discussion to show how they further the essay's argument.
- Only processed data that is central to the argument of the essay should be included in the body of the essay, as close as possible to its first reference.
- Tables should enhance a written explanation but not themselves include significant bodies of text. If they do, then these words must be included in the word count.
- Clarity in tables and graphs (legend) is important and students should not use unnecessary "over-formatting" that may detract from communication.
- A representative sample of raw data collected in large amounts by the student must be included in the core of the essay in a data table, including uncertainties and units. Any table should be designed to clearly display the information in the most appropriate form.
- Large tables of raw data collected by the student are best included in an appendix, where they should be carefully labelled.
- Graphs or charts drawn from the analysed data should be selected to highlight only the most pertinent aspects related to the argument. Too many graphs, charts and tables will detract from the overall quality of the communication.
- The use of a summary table and the combination of multiple graphs into one graph (family of curves) will avoid unnecessary repetitions.
- Students should illustrate key mathematical transformations with examples. Equations referred to in the text should be numbered.

Any material that is not original must be carefully acknowledged, with specific attention paid to the acknowledgment and referencing of quotes and ideas. This acknowledgment and referencing is applicable to audiovisual material, text, graphs and data published in print and electronic sources. If the referencing does not meet the minimum standard as indicated in the guide (name of author, date of publication, title of source and page numbers as applicable), and is not consistently applied, work will be considered as a case of possible academic misconduct.

A bibliography is essential and has to be presented in a standard format. Title page, table of contents, page numbers, etc must contribute to the quality of presentation.

The essay must not exceed 4,000 words of narrative. Graphs, figures, calculations, diagrams, formulas and equations are not included in the word count. Students must be aware that examiners will not read beyond the 4,000-word limit, nor assess any material presented past this.

### **Criterion E: Engagement**

#### **(Strands: Reflections on planning and progress)**

This criterion assesses the student's engagement with their research focus and the research process. It will be applied by the examiner at the end of the assessment of the essay, and is based solely on the candidate's reflections as detailed on the [RPPE](#), with the supervisory comments and extended essay itself as context.

Students are expected to provide reflections on the decision-making and planning process undertaken in completing the essay. Students must demonstrate how they arrived at a topic as well as the methods and approach used. This criterion assesses the extent to which a student has evidenced the rationale for decisions made throughout the planning process and the skills and understandings developed.

For example, students may reflect on:

- the approach and strategies they chose, and their relative success
- the [Approaches to learning](#) skills they have developed and their effect on the student as a learner
- how their conceptual understandings have developed or changed as a result of their research
- challenges they faced in their research and how they overcame these
- questions that emerged as a result of their research
- what they would do differently if they were to undertake the research again.

Effective reflection highlights the journey the student has engaged in through the EE process. Students must show evidence of critical and reflective thinking that goes beyond simply describing the procedures that have been followed.

The reflections must provide the examiner with an insight into **student** thinking, creativity and originality within the research process. The **student** voice must be clearly present and demonstrate the learning that has taken place.